MULTIMEDIA UNIVERSITY®

STUDENT ID NO

MULTIMEDIA UNIVERSITY

FINAL EXAMINATION

TRIMESTER 3, 2021/2022

EEL3156 RENEWABLE ENERGY TECHNOLOGY

(All Sections / Groups)

15 AUGUST 2022
09:00 A.M – 11:00 A.M.
(2 Hours)

INSTRUCTIONS TO STUDENTS

1. This question paper consists of 9 pages including this cover page with 5 questions only.

2. Attempt all 5 questions. All questions carry equal marks and the distribution of marks for each question is given.

3. Please print all your answers in the answer booklet provided.

Question 1

(a) Why energy is important to the national security of any rational country?

[2 marks]

(b) What is considered to be the main cause of global warming? How renewable energy helps to address the global warming issue?

[2 marks]

(c) Fig. Q1-1 shows a typical hydropower plant using a Francis turbine. Sketch the variation of water static pressure from the top of the reservoir to the tailrace. Your sketch should include the grid lines as shown in Fig. Q1-2. p_o is the atmospheric pressure.

[7 marks]

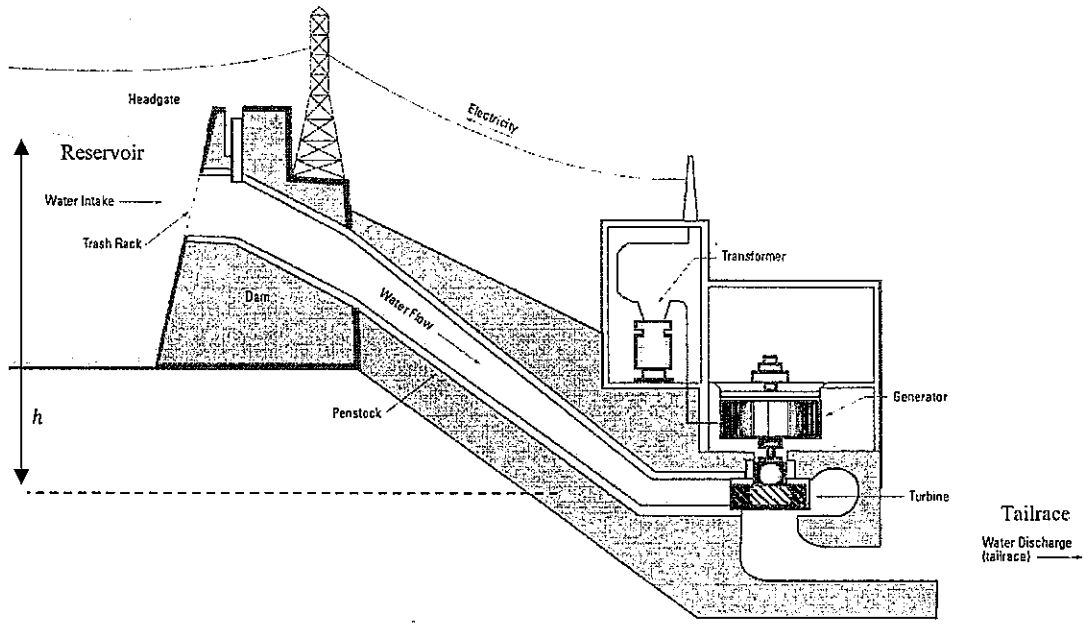

Fig. Q1-1

Continued ...

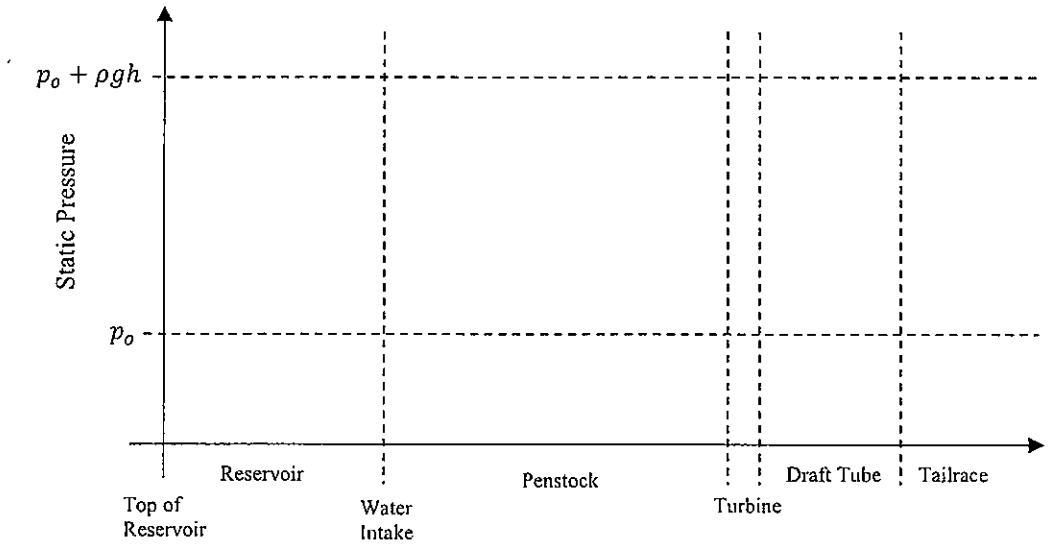

Fig. Q1-2

(d) Discuss three advantages of a large wind farm over a large hydropower station.
[3 marks]

(e) Discuss three advantages of offshore wind farm over onshore wind farm.
[3 marks]

(f) Compare and contrast the performance of 2-blade and 3-blade horizontal axis wind turbines.
[3 marks]

Continued ...

Question 2

(a) Given the solar spectrum shown in Fig. Q2-1, compute the solar irradiance. x is the last digit of your student ID.

[2 marks]

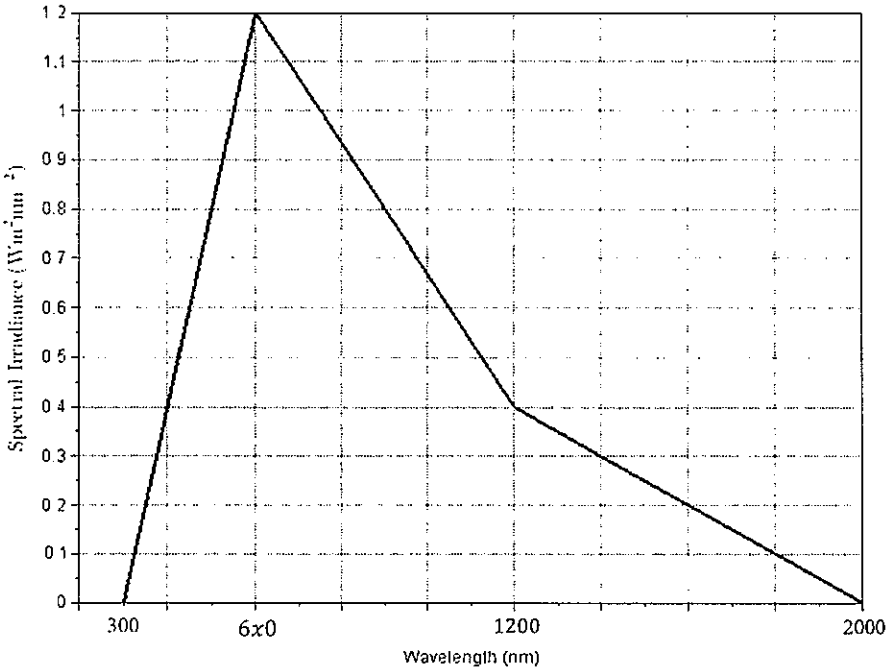

Fig. Q2-1

(b) Given the average daily variation of solar irradiance shown in Fig. Q2-2, compute the daily solar insolation. x is the last digit of your student ID.

[2 marks]

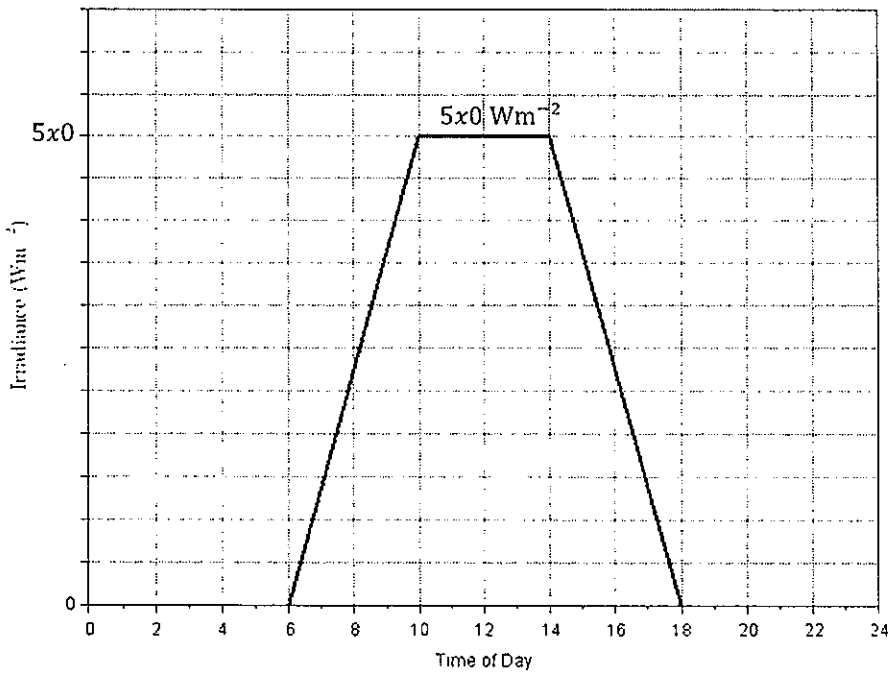

Fig. Q2-2

Continued ...

(c) "According to Kirchhoff's law of radiation, for a surface at a specified temperature, the absorptance and emittance are equal."

An important piece of information is missing from the above statement.

(i) What is missing from the above statement?
(ii) Explain how the missing piece allows the design of a selective surface which has good absorptance and poor emittance for solar thermal applications.

[5 marks]

(d) Sketch the IV (current-voltage) curves of a solar photovoltaic cell to show separately the effects of each of the following:

(i) reduced illumination,
(ii) reduced shunt resistance, and
(iii) increased series resistance.

[7 marks]

(e) Answer the following questions about biogas digester:

(i) Discuss one advantage and one disadvantage of elevated digester temperature.
(ii) Describe a scenario whereby elevated digester temperature is desired.
(iii) Describe a scenario whereby elevated digester temperature is not desired.

[4 marks]

Continued ...

Question 3

Note: x is the last digit of your student ID.

(a) A hydropower plant has the following specifications:

Available water head:	75 m
Flow rate per turbine:	$8x0\ m^3/s$
Turbine type:	Francis turbine with shape number ~1.5
Number of turbines:	$(20 + x)$ (each is paired with one generator)
Turbine efficiency:	94%
Generator efficiency:	96%
Capacity factor:	50%
Output frequency:	50 Hz
Water density:	$997\ kg/m^3$
Gravity acceleration:	$9.81\ m/s^2$

Determine the following:

(i) The annual electricity generation.

[5 marks]

(ii) The generator type if it is coupled directly to the turbine with 1:1 speed ratio.

[5 marks]

(b) A horizontal axis 3-bladed wind turbine has the following specifications at optimal operating condition:

Power coefficient, C_p:	$(40 + x)$ %
Tip-speed ratio, λ:	7
Attack angle, α:	5°
Blade length:	$(40 + x)$ m
Tower height:	80 m
Air density:	$1.2\ kg/m^3$

Determine the following for a wind speed of 13 m/s at optimal operating condition:

(i) The turbine's output power.

[3 marks]

(ii) The turbine's working torque.

[4 marks]

(iii) The tower toppling torque.

[3 marks]

Continued ...

Question 4

Note: x is the last digit of your student ID.

(a) A flat plate single glazing solar thermal collector has the following specifications:

Area:	$6\ \text{m}^2$
Irradiance:	$5x0\ \text{Wm}^{-2}$
Heat resistance:	$0.15\ \text{W}^{-1}\text{m}^2\text{K}$
Plate-fluid transfer efficiency:	85%
Glass cover transmittance:	90%
Absorber absorptance:	92%
Absorber emittance:	8%
Ambient temperature:	$30°C$
Plate temperature:	$(60 + x)\ °C$

Determine the system efficiency.

[5 marks]

(b) A solar photovoltaic system has the following specifications:

Area:	$6.0\ \text{m}^2$
Annual insolation:	$1x00\ \text{kWh/m}^2$
Maximum DC output power:	$900\ \text{W}_p$
Mismatch loss:	3%
Soiling loss:	3%
Cell temperature loss:	9%
Shading loss:	4%
Cable loss:	4%
Inverter loss:	3%
Availability loss:	5%

Determine the annual generation.

[5 marks]

Continued ...

(c) A biogas digester processes $1x000$ kg of wet manure with 75% moisture per day. Water is mixed to the manure to make a slurry of 50 kg solid per m^3. The retention time is 20 days. The biogas yield per unit dry mass is about 0.23 m^3/kg. Determine:

(i) the volume of the digester tanks and
(ii) the biogas production rate.

[5 marks]

(d) A hot aquifer has the following specifications:

Depth:	5 km
Thickness:	$5x0$ m
Average surface temperature:	$27°C$
Temperature gradient:	$4x$ $°C$/km
Useful temperature:	$> 60°C$
Porosity:	6%
Sediment density:	2700 kg/m^3
Sediment specific heat capacity:	840 J kg^{-1} K^{-1}
Water density:	1000 kg/m^3
Water specific heat capacity:	4200 J kg^{-1} K^{-1}
Cooling time constant:	50 years

Heat is extracted by natural hydrothermal circulation. Determine the water flow rate per km^2.

[5 marks]

Continued ...

Question 5

(a) Explain the importance of energy storage to utility electric grid operation. How is it related to grid-connected renewable power plants?

[5 marks]

(b) A residential home installed a solar photovoltaic system at rooftop and enrolled in the Net Metering Scheme. The electric grid reliability is very high. The solar panels were installed on one side of the rooftop. The solar irradiance is relatively uniform across all the solar panels. Propose a suitable inverter system for the above application scenario. Justify your proposal by comparing the different types of inverter systems.

[7 marks]

(c) Explain how smart grid could help in the supply-demand balance.

[3 marks]

(d) The Malaysian government has introduced a number of schemes to promote renewable energy production. An independent power producer (IPP) wishes to take advantage of one of these schemes to install a new solar farm.

a. Which scheme would you propose?
b. What benefits will the IPP gets from the proposed scheme?

[5 marks]

End of Paper